

Urusovskii's Geometry, Algebrodynamics and Universal Quantum-like Kinematics in Complex Space

Vladimir V. Kassandrov

(*Institute of Gravitation and Cosmology,
Peoples' Friendship University, Moscow, Russia*)

1 The Minkowski space-time model: does it really represent the ultimate physical geometry?

Nowadays, the Minkowski geometry necessarily constitutes the framework of any realistic physical geometry including its curved version in General Relativity, multidimensional schemes etc.

However, the true dimension and structure of real space (and time) is still unclear, and there is still no answer to the old question: “Why “*visible*” physical space is 3-dimensional?” And what in fact can be said on the origin and properties of *Time*?

From general physical viewpoint, the Minkowski space \mathbf{M} , together with the Lorentz group as its group of symmetry, possesses a number of remarkable and well-known properties (causal structure, universal velocity of propagation of interactions etc.), is well grounded in theoretical (symmetries of Maxwell and Lorentz equations) and purely experimental respects.

On the other hand, there are some known drawbacks of the STR paradigm (absence of the global evolutionary parameter, of phase relations, of time irreversibility etc.). And the most grievous fact is that \mathbf{M} *does not originate from first principles*, its mathematical structure is rather cumbersome and not distinguished in any aspect. Besides, assumption of \mathbf{M} as physical geometry *does not offer any key to comprehend the dynamics of fields and particles or the quantum properties of matter!*

Thus, one has to return back to foundations and seek for an internally exceptional structure of (extended) physical space-time which by itself could predetermine the properties of matter!

In this note, we briefly present two approaches to the establishment of the extended space-time structure and, combining them, demonstrate a purely classical, geometrical explanation of the quantum interference phenomena.

First approach (section 2) is the “6D treatment of Special Relativity” proposed by Igor A. Urusovskii in 1996-2011 (see [1] and references within). Key notions of his approach are: 1) universal light-like velocity of *any* particle in the whole 6D space, and 2) universal internal rotation of particles in the 3D space orthogonal to the physical 3D one.

Second approach (section 3) is my own “*algebrodynamical*” one (see references, say, in [2, 3]) in which one is also brought to a 6D geometry of special type. Key constituents arising naturally in the framework of algebrodynamics are (sections 4-6) 1) the ensemble of identical copies (“*duplicons*”) of one and the same particle and, 2) “*dimerous*” structure of electron which turns to be detectable only at the instants of merging of some two duplicons.

Finally, rather simple and natural combination of the above two approaches (section 7) immediately follows in a clear classical picture of the canonical *two-slit interference experiment* (section 8). Concluding remarks are presented in section 9.

2 On the 6D geometry of Urusovskii

Approach presented by I.A. Urusovskii in his original papers [4] is based in fact on the following two axioms (conjectures):

1) *universal light-like motion* of all of the pre-elements of matter (say, electrons) in the extended (3+3) physical space (so that *none particle is ever at rest!*). The principle was earlier discussed by F. Klein, Yu.B. Rumer, R.O. di Bartini et al and can either substitute or supplement the principle of *universal velocity of interaction propagation* in Special Relativity.

2) *universal periodical regular rotation* of particles along a circumference of *Compton radius* $R = \hbar/Mc$ in the additional 3D-space (orthogonal to the ordinary physical 3-space). This conjecture closely relates to the L. de Broglie's hypothesis on *internal frequency* ν (internal clocks) of elementary particles, $\hbar\nu = Mc^2$, to the conception of *Zitterbewegung* of E. Schrödinger etc.

Consequently, Urusovskii naturally assumed that *proper time* of a particle (being, say, at rest in “observable” 3-space and rotating, therefore, with constant speed c in orthogonal 3-space) *is proportional to the number of turns (or to phase increment) in its rotation in the internal space*.

Then for a particle moving uniformly with velocity v , velocity of rotation u is obtained from the principal relation $v^2 + u^2 = c^2$ and determined by the familiar Einstein's factor,

$$u = c\sqrt{1 - v^2/c^2}. \quad (1)$$

Thus, one comes to the canonical effect of *time deceleration* for a moving particle, even *apart of any specification of a transformation symmetry group*.

As to the latter, Urusovskii himself assumed it to be the Lorentz group since “the number of turns = the proper time interval” should be invariant, the same for any observer.

Moreover, according to Urusovskii, *all principal relations of STR including the dynamical ones, follow in fact from purely Newtonian physics in the entire 6D space, under projection onto the “observable” 3D space!* For more details of Urusovskii's approach see his original papers [4]; on further development of the theory see, e.g., [1] and references therein.

Let us remark now that the first postulate, on the universal light-like velocity, is obviously equivalent to the following relation for the increments of particle's coordinates $\{\mathbf{X}, \mathbf{Y}\}$ in the physical \mathbf{X} and internal \mathbf{Y} spaces:

$$dx_1^2 + dx_2^2 + dx_3^2 + dy_1^2 + dy_2^2 + dy_3^2 = c^2 dt^2. \quad (2)$$

We see thus that *one deals in fact with a Euclidean 6D space*, whereas the *global universal time should be considered as the metric on this space*, not as a coordinate! In this respect, the Urusovskii's viewpoint on his theory as on a “6D treatment of STR” is, at least, not evident or uniquely possible. Note also that recently a number of attempts were undertaken *to reformulate STR on the basis of the 4D Euclidean space* (see, e.g., [5, 6]).

As to the second postulate on regular internal rotation (in a 2D plane), it can be implemented for a particle at rest ($dx_1 = dx_2 = dx_3 = 0$) if one requires, say, in addition to (2):

$$dy_3 = 0, \quad dy_1^2 + dy_2^2 = ds^2 = R^2 d\varphi^2 = c^2 dt^2, \quad (3)$$

where the proper time increment ds turns to be the metric on *internal* space, whereas $d\varphi$ is the corresponding phase increment.

From further results obtained by I. Urusovskii in the framework of his 6D approach one can distinguish, say, 1) the *hydrogen spectrum* with account of its fine structure, 2) the *quark model* of nucleons, 3) a new treatment of gravitation (as a projection of *cosmological force* retaining particles in a Compton-order vicinity of \mathbf{R}^3), 4) a novel treatment of the *Universe expansion* (resolving a number of paradoxes in standard cosmology) etc.

Despite of these results (which one can give credence to or not), it is especially important that Urusovskii's approach allows *to link the space-time geometry with phase relations* (what could probably lead to a *geometrization of quantum theory*) and to directly deduce universal *kinematics* of particles (and, to some extent, their *dynamics* as well) from pure *geometry*!

However, in many aspects the Urusovskii's approach is certainly insufficient. Indeed, any general substantiation of the starting postulates is absent, the problem of *mass spectrum* is not resolved, structure and kinematics of *photons* (which, in the considered framework, should be treated as non-rotating in \mathbf{Y}) remain quite unclear etc. Evidently, a more general and mathematically profound approach is needed. In the following section we briefly present the algebrodynamical scheme that can aspire to such a role.

3 Main principles and results of algebrodynamics

In the *algebrodynamics* [7, 8] one assumes the existence of a (*exceptional* in its internal properties) *space-time algebra* (STA). The STA predetermines both the geometry of physical space-time (via the *automorphism group* acting as a Klein's symmetry group of metric), and the particle-field dynamics (via the *analyticity conditions* for functions-fields over the STA acting as field equations). Particles themselves may be confronted with *singularities* of functions-fields.

In the role of STA it had been considered the *algebra of complexified quaternions* (biquaternion algebra \mathbb{B}), equivalent to the matrix $Mat(2, \mathbb{C})$ -algebra. The \mathbb{B} -analyticity conditions – generalized *Cauchy-Riemann equations* (GCRE) – *turn to be nonlinear as a consequence of noncommutativity*. Thus, one deals in fact with fields with (self-)interaction!

Some consequences of GCRE are: emergence of gauge and spinor (twistor) structures, identical satisfaction of Maxwell and Yang-Mills free equations (for secondary derivative fields), *self-quantization* of electric charge [9] etc.

Note also that the geometry induced by the structure of \mathbb{B} -algebra is 4D in complex numbers = 8D in reals. Whether one (rather artificially!) reduces the coordinate space to real \mathbf{M} , the whole theory becomes *Lorentz invariant*!

A novel concept of physical Time had been also elaborated in which time manifests itself as a evolution parameter related to the condition of *local preservation of the primordial \mathbb{B} -field* (= principal spinor or twistor field in other equivalent representations).

Local evolution turns to be a *light-like transfer* of the primary \mathbb{B} -field. On this way, one comes to the concept of the *Flow of PreLight = Flow of Time* [10, 11]. Geometrically, particles manifest themselves as *caustics of the PreLight Flow* so that *whole matter is of a light-like nature*!

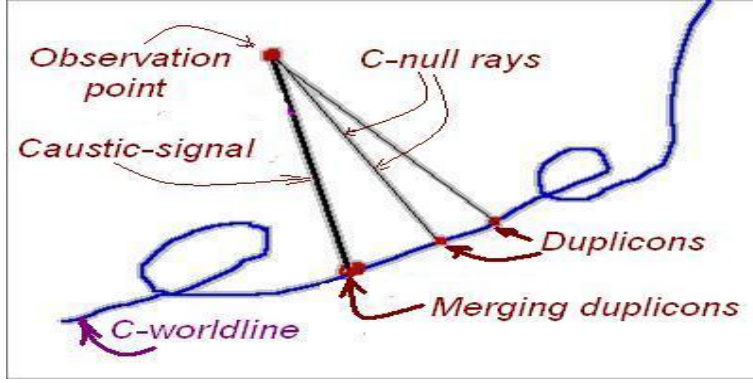


Figure 1: Duplicons and caustic formation.

4 Complex-quaternionic geometry of space-time

It is noteworthy, however, that none algebra is known which could give rise precisely to \mathbf{M} . Nonetheless, the considered 4D (in \mathbb{C}) = 8D (in \mathbb{R}) \mathbb{B} -induced geometry has the $SO(3, \mathbb{C})$ symmetry group which is 6-parametric and isomorphic to the Lorentz group!

On the other hand, \mathbf{M} does not contain any *phase-like* component, whereas the \mathbb{B} -induced geometry naturally decomposes into a Minkowski-type *macro-geometry* (defined by the modulus parts of complex coordinates) and *micro-geometry* of a “fiber”, related to their phase parts [12] and responsible, probably, for the wave properties of matter.

Actual \mathbb{B} -geometry of (extended) space-time turns to be 6D and resembles the geometry proposed by I. Urusovskii. It is dynamical in origin being closely related to universal kinematics of particles in the primordial complex \mathbb{B} -space. Such kinematics can’t be realized in real Minkowski space and results in a rather unexpected picture of Physical World. One can thus assume that *we really live in the complex space-time!*

5 Complex null cone and the concept of duplicons

Complex space-time geometry allows for realization of the *one-electron Universe* conjecture of Wheeler-Feynmann. On the *real* space-time background this is in fact impossible. Indeed, in real \mathbf{M} , according to the *retardation equation* (= *equation of the light cone*), one has only one unique object in the past that determines the field at a given point (for $v < c$; for tachions – more than one, see, e.g., [13]).

On the contrary, in complex space $Z = \{z_0, z_1, z_2, z_3\}$ equation of the *complex null cone*

$$(z_1 - \hat{z}_1(\tau))^2 + (z_2 - \hat{z}_2(\tau))^2 + (z_3 - \hat{z}_3(\tau))^2 = (z_0 - \tau)^2, \quad \tau \in \mathbb{C} \quad (4)$$

can have a great number of roots (dependently on the form of \mathbb{C} -trajectory $\hat{Z}(\tau)$), in accord, say, with the “principal theorem of algebra” (for polynomial functions $\hat{Z}(\tau)$).

Therefore, an observer “living in a \mathbb{C} -space” instantaneously receives the field signals from a lot of copies locating at the points on the same “complex worldline” (Fig.1). Thus, one actually deals with an ensemble of identical particle-like formations – “duplicons” [14, 15]. Points of

observation and location of a duplicon are connected by a \mathbb{C} -null straight line – “ray” (quite similar to the case of real \mathbf{M} where one deals with local light cones). These lines densely filling \mathbb{C} -space form a fundamental *null congruence* for which the \mathbb{C} -worldline itself play the role of its *focal line* [14].

6 Caustics as lightlike signals and “dimerous electron”

At some *discrete* instants (for a corresponding position of an observer in the \mathbb{C} -space) a *merging* of a pair of duplicons does take place (Fig.1). This relates to *multiple roots* of the \mathbb{C} -null cone equation (4). Again, such an event is in principle impossible in real \mathbf{M} .

At these moments strong *amplification* of electromagnetic and other fields emerges, along a null straight line connecting points of observation and of duplicons’ merging. Geometrically, these lines represent the *caustic locus* of the fundamental null congruence [14]. Physically, one observes a *lightlike pulse* – a *signal* coming from the points of duplicons’ mergings.

Thus, in the framework of a purely classical electrodynamics but contrary to the case of real \mathbf{M} background, in complex world there occur *quantum-like discrete radiation processes*!

One obtains therefore a *self-consistent relativistic dynamics of an ensemble of identical and causally connected “particles”*. It is evident, however, that (contrary to the Wheeler-Feynmann paradigm) individual duplicon *in principle* can’t be considered as a primary matter pre-element: only a pair of these can be detected, and only at discrete instants of their merging. We are forced thus to surmise that “electron” not only *consists* of two “halves” - duplicons, but does not in fact *exist* as a unique formation, except at discrete instants of merging - radiation - detection acts.

Conjecture on *electrons as dimerons* [3, 15] directly correlates with modern notions on “fractal charges” and “electron bubbles” [16], “light-shining-through-wall” effects [17] etc. It allows for *alternative explanation of the wave properties of matter* (section 8).

7 Links between complex and Urusovskii’s geometries

In full analogy with the case of real \mathbf{M} , the primary field and the caustic structure both *reproduce themselves along the null complex straight lines* – elements of the \mathbb{C} -null cone [14]. For their infinitesimals one has

$$dz_0^2 + dz_1^2 + dz_2^2 + dz_3^2 = 0. \quad (5)$$

Decomposing $dz_\mu = dx_\mu + idy_\mu$ and separating real and imaginary parts in (5), one obtains a system of *two quadrics* in \mathbf{R}^8 ,

$$dx_0^2 + dx_1^2 + dx_2^2 + dx_3^2 - dy_0^2 - dy_1^2 - dy_2^2 - dy_3^2 = 0, \quad (6)$$

$$dx_0 dy_0 + dx_1 dy_1 + dx_2 dy_2 + dx_3 dy_3 = 0. \quad (7)$$

First constraint (6) defines in fact *two 4D Euclidean (sub)spaces*; these are moreover mutually orthogonal as a result of the second equation (7). We can then define the *time increment* cdt as *common metric* on the both subspaces, so that relation (6) takes the form:

$$dx_0^2 + dx_1^2 + dx_2^2 + dx_3^2 = dy_0^2 + dy_1^2 + dy_2^2 + dy_3^2 := c^2 dt^2. \quad (8)$$

It is natural to assume that fundamental kinematics of matter pre-elements follows just from the condition of preservation of the primary field and caustic structure and satisfies therefore condition (5) or, equivalently, (7) and (8). According to these, *universal “eternal” motion of matter pre-elements occurs in both mutually orthogonal spaces \mathbf{X} and \mathbf{Y} , with one and the same, constant in modulus fundamental “velocity of light” c .*

Thus, complex geometry leads by itself to satisfaction of the first postulate of the Urusovskii’s scheme. Specifically, for a particle which is at rest in the “physical” 3D subspace of \mathbf{X} , one obtains making use of (7) and (8):

$$dx_1 = dx_2 = dx_3 = 0, \rightarrow dy_0 = 0, \quad dx_0^2 = c^2 dt^2 = dy_1^2 + dy_2^2 + dy_3^2, \quad (9)$$

so that it necessarily moves with the speed of light in the 3D subspace of \mathbf{Y} .

The geometry allows moreover for exact *rotating configurations* considered by Urusovskii. To obtain these, one can require, say, in addition to (9):

$$dy_3 = 0, \quad dy_1^2 + dy_2^2 = R^2 d\varphi^2 \quad (= c^2 dt^2 = dx_0^2), \quad (10)$$

We see therefore that the increment of zeroth coordinate dx_0 (generally, of $dz_0 = dx_0 + idy_0$), invariant under transformations from the symmetry group $SO(3, \mathbb{C})$ of \mathbb{B} -algebra, appears in the role of a *proper time interval* [12], in full correspondence with the Urusovskii’s picture. It is clear, however, that much more general configurations are admissible, namely (for a particle resting in 3D subspace \mathbf{X}), an arbitrary light-like motion in the orthogonal 3D subspace \mathbf{Y} .

8 Phase of internal revolution and quantum interference

For Urusovskii’s configurations applied to a duplicon its *phase change* $d\varphi$ along a trajectory is proportional to the increment of proper time ds ,

$$d\varphi = ds/R, \quad (11)$$

where R is the radius of internal rotation which, according to Urusovskii, is equal to the Compton length of the duplicon. However, for correspondence with quantum theory (see below), we shall assume for this radius

$$R = \hbar/2Mc, \quad (12)$$

where M is taken to be the mass of the particle (electron) associated with duplicons.

In [3, 15] it had been already demonstrated that, together with the “dimerous electron” conjecture, fundamental relation (11) along with (12) leads to a purely classical explanation of the canonical two-slit experiment. Specifically, one can consider this as two successive mergings of a pair of duplicons at space-time points where they can be detected by an observer (Fig.2). Since these mergings occur in fact in the extended complex space-time, the coordinates of two duplicons should coincide whereas their phases could differ to $2\pi N$, $N \in \mathbb{Z}$. Thus, the phase shift $\Delta\varphi$ for a pair of duplicons between their successive mergings should be

$$\Delta\varphi = \Delta \int d\varphi = 2\pi N, \quad (13)$$

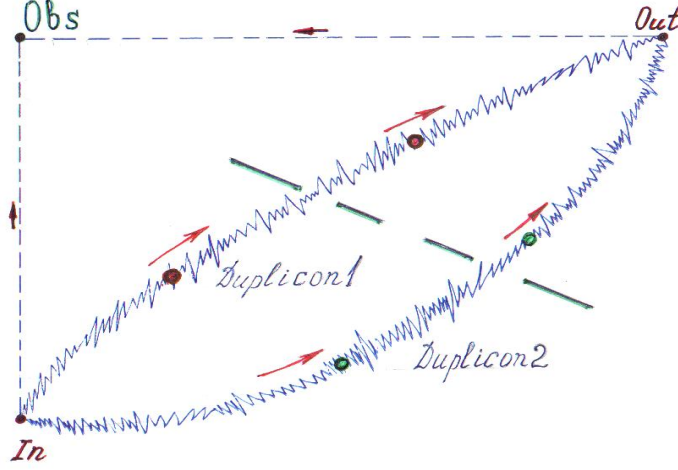


Figure 2: Successive mergings of duplicons in a two-slit experiment.

or, making use of (11) and (12),

$$\frac{2Mc}{\hbar} \Delta \int ds = 2\pi N. \quad (14)$$

This is *general relativistic invariant condition for two successive mergings of duplicons* which substitutes the canonical condition for interference maxima. Indeed, in the first order of non-relativistic approximation $v/c \ll 1$, making use of representation

$$ds = cdt\sqrt{1 - v^2/c^2} \approx cdt - vdl/2c, \quad (15)$$

with $dl = vdt$ being the path length increment, one obtains instead of the principal condition (14):

$$\Delta \int \frac{dl}{\lambda(l)} = N, \quad (16)$$

where $\lambda(l)$ denotes the de Broglie's wavelength (generally, variable along a trajectory),

$$\lambda(l) := h/Mv. \quad (17)$$

Obviously, equation (16) corresponds to the familiar condition for interference maxima (for constant velocity it takes the form $\Delta L = N\lambda$). However, general relativistic condition in the algebrodynamics is represented just by equation (14) which may be rewritten in the form

$$\Delta S = \frac{N}{2} \Lambda, \quad (18)$$

where S is the length of a 4D worldline in real \mathbf{M} for one of duplicons (between two successive merging events), and $\Lambda = h/Mc$.

Thus, in complex algebrodynamics, in the idealized situation, one deals with a δ -shaped probability distribution for interference pattern since duplicons can merge and be thus detected only at some discrete space points specified by the condition (18). However [3], due to

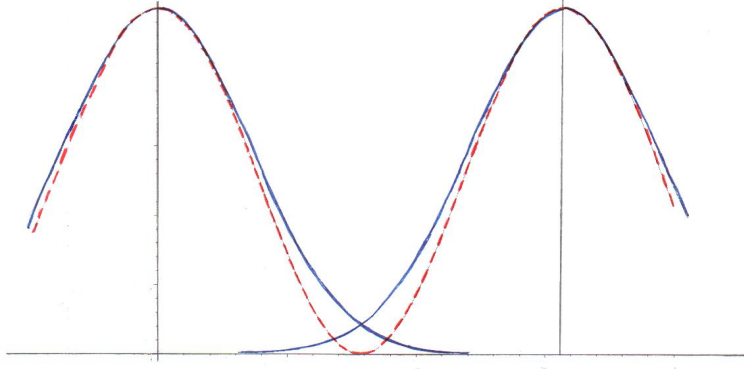


Figure 3: QM vs AD distributions of probabilities in a two-slit experiment.

statistical errors in a real experiment (during preparation, detection processes etc.) the probability distribution smears and takes, near a single maximum, a Gaussian-like form (Fig.3, solid line)

$$\sim \exp(-\Delta x^2/\Lambda^2), \quad (19)$$

while the canonical wave-like distribution is of a form (Fig.3, dashed line)

$$\sim \cos^2(\Delta x/\Lambda). \quad (20)$$

In vicinity of a maximum these coincide up to the 3-d order derivative. Nonetheless, the distinction (see Fig.3) could be revealed in a suitable quantum interference experiment.

9 Concluding remarks

We have demonstrated that quantum interference phenomena can be explained in a purely geometrical manner whether one adopts two independent fundamental conjectures dealing with 1) universal kinematics of matter pre-elements (rotation with velocity of light in the additional space) and, 2) dimerous nature of electrons and, probably, other elementary particles (detectable at some particular instants of merging of their constituents – duplicons).

We have shown that these two conjectures are compatible with each other but, unfortunately, first one does not follow directly from the fundamental algebraic dynamics in complex space, so that Urusovskii's universal kinematics remains up to now an intuitive though very attractive hypothesis.

Nonetheless, let us mention that, actually, there exist much more rigid restrictions on kinematics of pre-particles in the complex-quaternionic space than those revealed in section 7. These are based on twistor structure of the primary \mathbb{B} -field and make the Urusovskii's conjecture even more realistic.

References

- [1] I.A. Urusovskii, in: *Proc. Int. Sci. Meet. on Physical Interpretations of Relativity Theory (PIRT-2009)*, eds. M.C. Duffy et al. – Moscow-Liverpool-Sunderland, Bauman Tech. Univ. Press, 2009, P. 173-184.

- [2] V.V. Kassandrov, in: *Proc. Int. Sci. Meet. on Physical Interpretations of Relativity Theory (PIRT-2003)*, eds. M.C. Duffy et al. – Moscow-Liverpool-Sunderland, Bauman Tech. Univ. Press, 2003, P. 23-33; www.arxiv.org, hep-th/0312278.
- [3] V.V. Kassandrov, in: *Proc. Int. Sci. Meet. on Physical Interpretations of Relativity Theory (PIRT-2009)*, eds. M.C. Duffy et al. – Moscow-Liverpool-Sunderland, Bauman Tech. Univ. Press, 2009, P. 95-104; www.arxiv.org, 1105.3183.
- [4] I.A. Urusovskii // *Zarubezhnaja radioelektronika* (in Russian), 1996, No.3, P. 359-367; 1999, No. 6, P. 64-74; 2000, No. 6, P. 66-77.
- [5] J.M.S. Montanus // *Hadronic Journal*, **22**, 1999, P. 625-673.
- [6] A.B. Pestov, in: *Spacetime Physics Research Trends: Horizons in World Physics*, **248**, ed. A. Reimer. – NY, Nova Science, 2005, P. 1-29; www.arxiv.org, gr-qc/0308075.
A.B. Pestov, www.arxiv.org, gr-qc/051214.
- [7] V.V. Kassandrov, *Algebraic Structure of Space-Time and the Algebrodynamics*. – Peopl. Frien. Univ. Press, Moscow, 1992 (in Russian);
V.V. Kassandrov // *Gravit. & Cosmol.*, **3**, 1995, P. 216-222; www.arxiv.org, gr-qc/0007027.
- [8] V.V. Kassandrov, in: *Space-Time Structure: Algebra and Geometry*, eds. D.G. Pavlov et al. – Moscow, Lilia Print, 2007, P. 441-473; www.arxiv.org, 0710.2895.
- [9] V.V. Kassandrov, in: *Has the Last Word been Said on Classical Electrodynamics*, eds. A. Chubykalo et al. – Rinton Press, 2004, P. 42-66; www.arxiv.org, physics/0308045.
- [10] V.V. Kassandrov, in: *Space-Time Structure*, eds. D.G. Pavlov et al. – Moscow, TETRU, 2006, P. 99-118.
- [11] V.V. Kassandrov, in: *On the Road to Understanding the Time Phenomenon*, ed. A.P. Levich. – Moscow, Progress-Tradition, 2009, P.117-150 (in Russian).
- [12] V.V. Kassandrov // *Gravit. & Cosmol.*, **11**, 2005, P. 354-359; www.arxiv.org, gr-qc/0602088.
- [13] B.M. Bolotovskii, V.P. Bykov // *Sov. Phys. Uspekhi*, **33**, 1990, P. 477-487.
- [14] V.V. Kassandrov, in: *Proc. Int. Sci. Meet. on Physical Interpretations of Relativity Theory (PIRT-2005)*, eds. M.C. Duffy et al. – Moscow-Liverpool-Sunderland, Bauman Tech. Univ. Press, 2005, P. 42-53; www.arxiv.org, gr-qc/0602064.
- [15] V.V. Kassandrov // *Phys. Atom. Nuclei*, **18**, 2009, P. 813-827; www.arxiv.org, 0907.5425.
- [16] V.P. Bykov // *Phys. Uspekhi*, **49**, 2006, P. 979-985.
- [17] R. Sikivie // *Phys. Rev. Lett.*, **51**, 1983, P. 1915-1920.